THE TELEGRAPHIC JOURNAL.

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DUPLEX TELEGRAPHY.

By W. H. PREECE, Memb. Inst. C.E. and Soc. T.E.

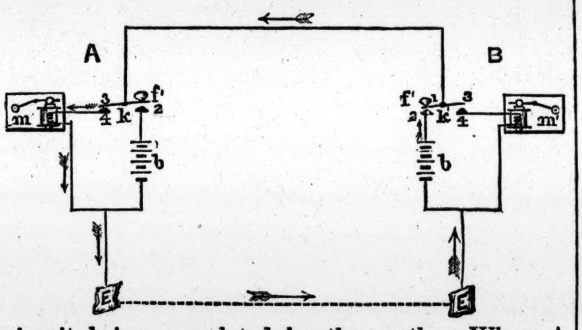
Duplex telegraphy, which has lain dormant in England for nearly seventeen years, has recently received great attention from all telegraphists, owing to its successful introduction in America by Mr. Stearns. This method of working consists in telegraphing in opposite directions upon one wire at the same time. It implies that while A is working to B, B can also work to A upon the same wire.

Before explaining how this apparently impossible operation can be performed, I will first show how A usually works to B, by means of an ordinary Morse recording-instrument,

A possesses a battery (*b*) whose number of cells depends upon the distance which separates A and B; a key (*k*) which on being depressed (as shown at B) by the pressure of the fingers at *f'* brings the points 1 and 2 in contact, causing the current to flow from the battery (*b*), and which in its normal position (as shown at A) remains with the points 3 and 4 in contact, thereby permitting any current arriving from B to flow through the Morse apparatus or receiver (*m*).

B possesses the same apparatus as A. They are connected up, as shown in the diagram (Fig. 1), the circuit being completed by the earth. When A works to B he depresses the key (*k*), sending a current to B, which, passing through the receiver (*m*), records its mark, and for every current so sent a mark is made. Now when B works to A precisely the same thing occurs—every depression of the key at B occasions a mark to be recorded upon the receiver at A, through the passage of a current from B to A. It is evident that if the batteries at the two places be similar in every respect, and the insulation of the wire be perfect, the currents from each station will be exactly equal in strength. The currents from A to B may be in the same or in an opposite direction to those from B to A. It matters not—the effect upon the recorder is just the same. I have shown them in the diagrams to flow in the opposite direction, and therefore, for the present, we will so consider them. We will also assume, for the present, that the current received at either station is exactly equal to that going out of it.

Fig. 1.



Now what happens when these two stations try and work to each other at the same time? We have a current from A flowing to B in one direction, and we have a current from B flowing to A in the opposite direction: and since these currents are equal, if they tend to flow at the same time, the effect must be *nil;* they, in fact, destroy each other; no current can be formed,—hence with such apparatus no marks can be registered at either station. But what if we can avail ourselves of this destruction of the current to register marks? That is, if we let one instrument be such that it registers when the current is *formed*, and also when the current is *destroyed*. If we can do that duplex telegraphy is possible; A can work to B while B works to A.

This problem was first solved by Dr. Gintl, an Austrian telegraph director, in 1853. Modifications of his solution have been made in Germany by Siemens, Frischen, and others; in England by the writer, and Mr. Eden of Edinburgh; and in America by Mr. Stearns. There are three methods adopted: first, that of *equation;* second, that of *difference;* third, that of *leakage*.

1. *Equation*, which was the method originally invented and applied by Dr. Gintl.

The connections are so arranged, as shown in Fig. 2, that the receiver at each station is always in circuit, so that the currents, whether they are sent by A or received from B, pass through it; but it is so constructed that when A alone is working no effect is made on its own receiver by the outgoing current. How is this done? The electro-magnet, E', Fig. 3, which is shown here in plan, is wound with two wires, of exactly equal dimensions and resistance, either of which operates equally upon the iron core when traversed by the same or an equal current. The character of the magnetic polarity imparted to an iron core by a current depends upon the direction of the current. If a current in one direction produces a *north* pole at at the uper end, a current in the reverse direction produces a *south* pole at the same end. If these currents acted simultaneously, the result would be no polarity at all, for the tendency to induce the one

Fig. 2.

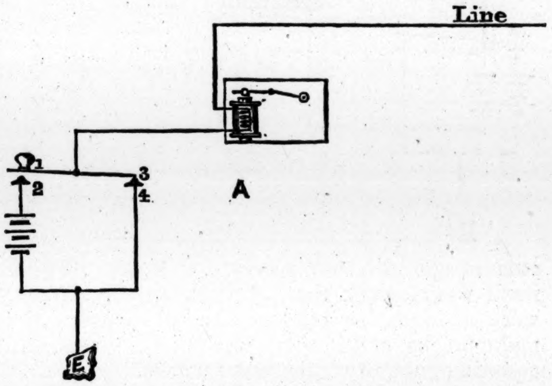
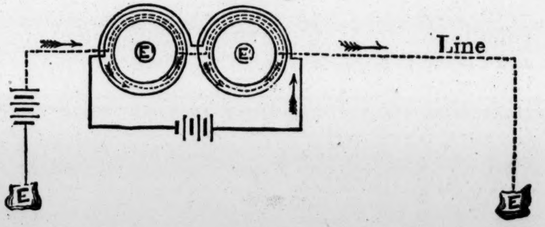
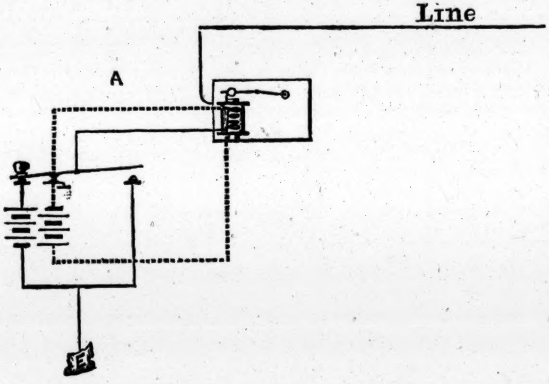


Fig. 3.



pole is exactly neutralised by the tendency to induce the other pole. Supposing that while the line current is traversing one of these wires, in Fig. 3, in the direction shown by the arrow, a second current—of exactly similar strength—is flowing through the other wire in the opposite direction, then the influence of one current on the iron core must be neutralised by that of the other, and the effect upon the electro-magnet must be *nothing;* and therefore if the electro-magnet of the receiver at A be thus constructed, while that station is sending to B its own receiver remains unaffected. Gintl called this second or local current the "equating" current. A key, Fig. 4, with duplicated points of contact was used which, whenever depressed, sent two currents, the one, the "line" current, from the line battery passing through the line wire working the receiver at B, and the other the "equating" current from the second battery flowing through the local circuit, rendering nugatory the effects of A's line current upon its own receiver. Either current of itself would work the receiver, so that if there were no equating current, the line current would make marks, and if there were no line current, the equating current would make marks.

FIG. 4.



Now under such circumstances, when A alone is working to B, no impression whatever is made upon its own receiver, but B's receiver registers its marks in the usual way. Again, when B alone is working to A, A's receiver registers its marks in the usual way, while the effect on that of B is neutralised, but when A is working to B at the same time that B is working to A, then every one of B's currents destroys A's line current, and therefore causes the equating current to make a mark at A, so that in fact B's marks are not lost, for those which would have been registered by the line current *from* B are registered by the equating current *at* A. Hence the receiver at A continues to register all the signals sent by B, whether A be working at the same time or not, some of these signals being registered by the line current, and some by the equating current. In the same way the receiver at B continues to record all the signals sent by A. Thus while A is sending messages to B, B can also send messages to A upon the same wire and at the same time.

I have assumed that the current received at A from B is exactly equal to that proceeding from A to B, and that, therefore, the one current exactly neutralises the other. But this is neither necessary, nor was it the fact in practice, for owing to the effects of bad insulation, the received current is always much weaker than the sending current. Hence the effect of the current received at A from B is not to neutralise the whole of the current proceeding from A to B, but only a portion of it, and therefore to weaken it, so that the "equating" current which is not affected preponderates and registers marks by this preponderance. The *difference* in the strength of the two currents when both stations are working is very nearly equal to the strength of the current received at A when B alone works, so that the marks, whether made by the received line current or by the preponderating "equating" current, are of the same intensity.

Again, I assumed that the batteries at each station were similar in every respect, but this also is neither necessary, nor the fact in practice, for, as the above remarks show, it is not by the absolute neutralisation of the line current that the "equating" current operates, but by the difference of its strength and that of the line current.

Nor is it necessary that they should act in the same direction, for if the current from B flows in the same direction as that from A, and the two stations work simultaneously, the effect is not to weaken the resultant current but to strengthen it, and therefore still to produce a preponderance of the one current over the other, and therefore to register signals; but in this case the marks made at A, when both stations are working simultaneously, are not made by the excess of the equating current over the line current, but by the excess of the sending, or outgoing current, over the equating current at A.

I also described the electro-magnet of the receiver as being wound with two wires of equal dimensions, and traversed by currents of equal strengths, but this is neither necessary, nor was it the fact. The equating battery was a small battery of one or two cells, and the local wire a thick one; it was only necessary to arrange its resistance and the number of its convolutions, so that the influence of its current upon the electro-magnet should exactly equal, but in the reverse direction, that of the outgoing line current. The principle remained the same.

The writer applied, in 1855, this principle to Bain's chemical printing instrument. The plan is easily comprehended after the foregoing description from an inspection of the diagram, Fig. 5. The opposition of the line and local currents neutralises the effect of the outgoing current on the chemically prepared paper, while the incoming current produced the same effect, whether the stations were working separately or simultaneously. Gintl also seems to have tried this plan with good results (see Sabine's "Telegraphy," p. 122).

This equating principle was Gintl's original or theoretical solution of the problem of duplex working. Experimentally it worked beautifully, but when essayed in practice it failed to answer thoroughly. This was due to many causes.

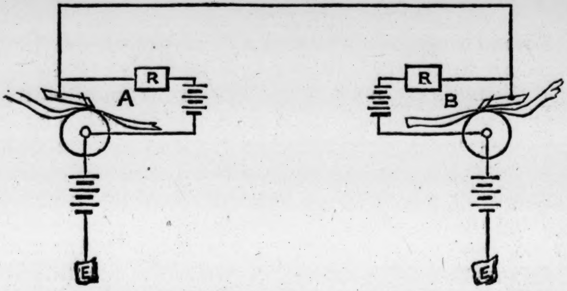
1. There is a short interval during the depression of the key when the circuit is broken, when both equating and line currents fail, and when marks must be lost.

2. The line and equating batteries are doing different work, and, therefore, it is almost impossible to retain their electromotive force and internal resistance uniform.

3. The resistance of the equating circuit is constant, but that of the line circuit is varying every

minute of the day, hence frequent compensation and adjustment became necessary. Rheostats were scarcely known in those days, and means of adjustment were difficult.

Fig. 5.



4. The effects of static induction upon land lines were not known.

5. Magnetic *inertia*, or the effects of electro-magnetic induction on apparatus, were not understood.

Some of these causes of irregularity were remedied or reduced by the principle of *difference*.

MATHEMATICS FOR NON-MATHEMATICIANS.

(Continued from p. 182.)

By WILLIAM PAGET HIGGS, LL.D.

Division I.—The Algebra of Constant Quantities.

Multiplication, Involution, and Exponents.

Early in our studies we understood that if a be taken as a kind of short way of writing one apple, $2a$ will stand for two apples; but if a is taken to represent two apples, then $2a$ will stand for four apples; and so on. Similarly, if a be taken to represent the abstract number one, then $2a$ will be equal to 2. If a stand for 2, then $2a$ will equal 4. Thus the figure 2 is a multiplier, and all multipliers in similar position are termed *coefficients*. In the instance given the coefficient of a is 2, a numerical coefficient.

Coefficients are *numerical* and *literal*. If it is understood that n shall represent any determined number, then na will represent n times a, and n will be the literal coefficient of a.

It is convenient to indicate the operation of *multiplication* by letters placed together as na. This operation is indicated also by the sign × between two quantities, as $a\times b$, or by a point $\cdot$,[*] as $a{\cdot}b$. Thus ab, $a\times b$, and $a{\cdot}b$ are identical in meaning.

It will at once be seen how we may indicate multiplication of a bracketed quantity, as—

$$2(a+b)=2a+2b, \text{ or } n(a+b)=na+nb.$$

And how we may obtain a rule for the removal of the brackets when a coefficient stands before them,—that is, when removing brackets, to multiply all the terms of a bracketed quantity by the coefficient. As instances the reader may trace out the meaning of the following equations:—

$$3ab(x+y)=3abx+3aby.$$
$$n(ax+by)=nax+nby.$$
$$a(b+c)\times(d+e)=(ab+ac)\times(d+e)=$$
$$=abd+abe+acd+ace.$$

We have learnt that a *coefficient* is a *multiplier*. It is a common error arising from want of accuracy in limiting the meaning of words, to call a constant quantity that is to be added, subtracted, or to be a divisor, by the name of a coefficient. Such a quantity is more conveniently termed a *constant*. In the expressions $x+c$, $x-c$, c is a constant; in the expression cx, c is a coefficient.

The idea of multiplication includes the multiplication of quantities having like and unlike signs,—that is, we may be called upon to perform the operation of multiplying a positive quantity by a positive quantity, a negative quantity by a positive quantity, and conversely. The multiplication of a positive quantity by another positive quantity will clearly result in a positive product.[*] But the result of multiplying together two negative quantities, or a negative and positive quantity is not so apparent. Let us look more closely at the question.

There are four possible cases of multiplication, viz.:—

$$a\times b,$$
$$-a\times b,$$
$$a\times -b,$$
$$-a\times -b.$$

The first two are easily understood. In the first case we take a in the number of times represented by b; in the second case we take $-a$, b times. That is, if a is equal to 2, and b represents 3, then $a\times b$ is equal to 6, and $-a\times b=-6$, or -2 repeated three times. In the third case, where a is to be multiplied by $-b$, we are directed by the sign of operation to repeat a the number of times represented by $-b$, and as we may always reverse the process and repeat $-b$ the number of times represented by a, the product is again -6. Thus, in both cases where the quantities have *unlike* signs, the product is a minus or negative quantity.

The remaining case of like signs (that of multiplying two negative quantities) it is not so easy to grasp. We must arrive at the result indirectly. The question, numerically stated, is to multiply -2 by -3. If we increase the multiplier (-3) by 4, making it equal $+1$, the product $(=-2)$, will, of course, be four times too great, and to arrive at the true result we must subtract (4 times -2), or -8. Now $-2-(-8)$ is, as we have seen when studying subtraction, equal to $+6$.

We have thus arrived at the conclusion, which may be stated as a rule, that the multiplication of quantities having like signs gives a positive product, and the multiplication of quantities having unlike signs gives a negative product. Professor Young concisely states the rule.

Like signs give PLUS; *unlike signs*, MINUS.

Involution and Exponents.

If we desire to multiply a by itself, we may state the result as aa, and repetition of the operation would give aaa. Custom has, however, established a more convenient expression than aa or aaa, namely, a^2 or a^3.[†] The small figure ^{2} or ^{3} is termed the *exponent*. An exponent shows the number of times a quantity is to be multiplied by itself, or in technical phraseology the "power to which the quantity is to be raised." The first power of a given quantity, or a^1, is equal of course to the quantity itself. The second power of a given quantity, or a^2, is termed the "square" of that quantity. The third power is termed the "cube." Other powers are known by their ordinal names. The exponent of a *power* must be an integer or whole number; if the exponent be fractional it indicates a "root," a matter we shall presently describe. The term "square" is derived from the fact that if we wish to arrive at the superficial contents, or area expressed in square measure of a given space, we may, by multiplying by itself the linear measure of the side of the space, obtain this area; and if again we multiply this area by the given quantity, we have the expression in cubic measure of the solid contents of the space. When referring to geometrical expressions, we should remember that if we represent a line by a, the square built upon that line will be a^2, the solid or cube built upon the square will be a^3. Thus upon a line of two units length—

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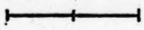
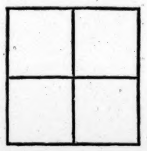
[*] To prevent confusion with decimal fractions the dot is not employed in numerical calculation.

[*] The result of multiplying two quantities is termed the *product*; the result of their addition, the *sum*.

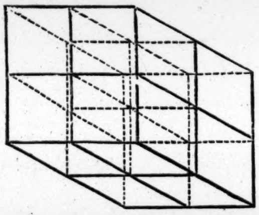
[†] The reader must not confound this expression with $2a$ or $3a$. a^2, means a times a; a^3, a times a times a; but $2a$ or $3a$ means twice or thrice a



if we build a square we have, as result, four square units—



and if upon this square we erect a cube, we have eight cubic or solid units—



Geometricians give to the line, the square, and the cube, the term of "space of one, two, and three dimensions," respectively. Space of a fourth dimension would be practically inconceivable.

a may then represent space of one dimension,
a^2 " " " two dimensions,
a^3 " " " three ditto.

To be familiar with these ideas, which are really the result of a false analogy, will be necessary when we wish to study the principles of the Differential Calculus; till then they must remain in abeyance, while we consider the use of Exponents as Logarithms.

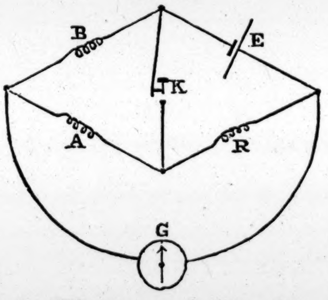
THE SHAH AND THE ELECTRIC LIGHT.—During the visit of the Shah to the Royal Albert Hall, when the orchestra struck up the first bars of the National Anthem, six electric lights placed at equal distances round the gallery were simultaneously displayed, and the brilliant flashes were thrown by reflectors on the splendid group of uniforms blazing with diamonds. The Shah was evidently quite as much delighted as any one else, while the Princess of Wales briefly indicated to his Majesty the nature of the light which made his and her jewels gleam again with tenfold brilliancy. The arrangements were made by Messrs. Tisley and Spiller.

MANCE'S METHOD FOR DETERMINING THE RESISTANCE OF BATTERIES AND GALVANOMETERS.

SEVERAL correspondents have addressed questions to this Journal asking for information as to the use of Mance's method for the determination of battery and galvanometer resistance; and as much relating to this method is scattered through the scientific press, better than to refer to these separate articles will be to collect into a few words the essentials of the system.

As many of our practical readers know, the measurement of the resistance of a battery is difficult, since the resistance is subject to considerable variation during the time of making the measure. And because the constancy of strength of current passing in a circuit is dependent upon the constancy of the resistance of that circuit, many methods which are not cognisant of this variation in strength of current give only doubtful results. In Mance's method the results are to be depended upon, because the variation of strength of battery current does not affect the measurement of the resistance, since all branches are proportionally subject to the variation. The method consists simply in substituting the battery of which the resistance is to be measured for the resistance in one branch of the Wheatstone bridge, and adjusting the resistances until the needle of the galvanometer which is deflected from zero maintains that deflection constant, when contact at the cross wire of the bridge is made and broken. In the following illustration A, B, E, and R are the four sides of a Wheatstone bridge, K a contact key, G the galvanometer, E being the battery whose resistance is to be measured. Now when AE=BR the resistance F becomes determined, or, supposing A and B to be two equal resistances, E and R will be equal. Having placed the battery in one of the branches of the bridge, we make and break contact at K, and if there be no change in the deflection we know that AE=BR, and $E=\frac{BR}{A}$. Practically the result is independent of the galvanometer resistance. It is convenient to give to the constant branches of the bridge a ratio by which the unplugged resistance may be multiplied.

FIG. 6.



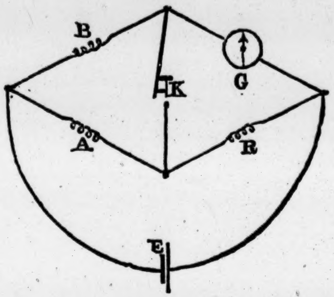
The method admits very easily of experimental proof; for if we make the resistance R great, we shall have a larger deflection when K is open than when pressed down; but if R is small, then when K is pressed down we shall have the larger deflection. Evidently there must be some value for R at which the closing or opening of K does not affect the deflection; and if A and B are equal, this value will be the resistance of E.

Sir William Thomson has adapted Mance's method to measuring the resistance of the galvanometer when in actual use. The measurement is effected simply by interchanging the galvanometer and battery, as in the next illustration. If $AG-BR=0$ no current will be produced in K, and consequently the deflection of the galvanometer will remain the same whether K be closed or open. When this occurs the resistance of—

$$G=\frac{BR}{A}.$$

Thus the galvanometer is made to measure its own resistance at one constant deflection.

FIG. 7.



Students' Column.

Practical Notes on Resistance Coils.

THE coils, to be accurate, must be so constructed that the connectors or plugs do not give appreciable resistance. The plugs should not be handled, except by the ebonite handle intended for the purpose, because the adherence of a film of dirt or grease to the plugs would interpose resistance.

The temperature of the bobbins should be uniform—best maintained by making the bobbins hollow and of large diameter, placing them all in one box. For small resistances long lengths of large gauge wire are better than short lengths of fine wire, as the former are less liable to derangement from a powerful current, and may be more easily adjusted. When the equal arms of a Wheatstone bridge are required always accurately at the same temperature, it is convenient to wind them on one bobbin.

Prof. Fleeming Jenkin recommends that the wires should be insulated with two coatings of silk saturated with solid paraffin.

To avoid induction and magnetic effect the wire is doubled upon itself before being wound upon the bobbin, thus giving an equal number of turns in opposite directions.

There should not be any soldered joints inside the coils, owing to the danger of short-circuiting and break in continuity. Solderings with acid should never be employed.

DUPLEX TELEGRAPHY.—We draw the attention of our Senior Students to the papers on "Duplex Telegraphy, by Mr. W. H. Preece, C.E., which appear in another page. It will be found that the subject is treated fully and simply.

ERRATA.—We regret that Mr. Sabine's recent paper, on "*Retardation in Overhead Wires*," was sent to press before the corrected proof had come to the printer's hands. The following errata should be replaced by our students:—

P. 185.—Last line but one, *for* 377×10^{-9} *read* 463×10^{-9}.

P. 186.—Table, 5th line, *for* 19,500 *read* 91,500 (miles per sec.)

It may be remarked that when Walker experimented in the reverse direction (*i.e.* New York to Boston) he found the time 0·012 sec., which represented an apparent speed of 18,000 miles per sec. and a coefficient of $a=1458\times10^{-9}$.

P. 186.—Same table, 6th line, *for* 377 *read* 463.

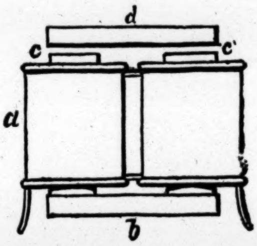
[ED. T. J. & E. R.]

PAPERS FOR JUNIOR STUDENTS.

Telegraphic Instruments.

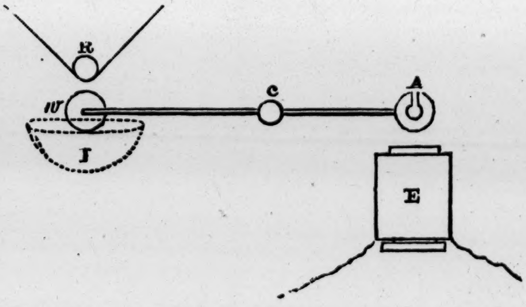
WE have learnt (see page 127) that "electro-magnets are generally made in a U-shape, two bobbins or spools, *a* (see Fig 8) being filled with covered copper wire, and the cores, *c c'*, of soft iron fixed upon a soft iron connecting-bar. The bobbins are virtually continuations of one bobbin. The poles of the magnet are the ends of the core, *c c'*, and the piece of soft iron upon which the magnet exerts its force is termed the *armature*." As long as there is a current passing in the coils of the electro-magnet, so long will the armature be attracted by the magnetism developed in the soft iron cores. If we pass a current for a short time, the armature will be attracted for a short time; and if for a long time, the armature will be held down for a long time.

FIG. 8.



It is clear that the electro-magnet may be at any distance from the source of the current, if it be connected with that source by conducting wires. So that we have a means of signalling between two distant places by attractions of the armature of long and short duration. These attractions may be registered by a very simple mechanical contrivance, illustrated in the following woodcut.

FIG. 9.



For the reason given at page 137, the armature, A, takes a circular form. It is attached to a light rod or bar, centred at a fulcrum, *c*, and carrying at its other extremity a small wheel or disc, *w*. This wheel dips into a semi-circular basin, I, which contains ink. The periphery of the wheel becomes covered with ink, and is made to record the depressions of the armature, A, by being brought into contact with a paper riband, R, drawn forward by clockwork. At every attraction of the armature, A, the wheel, *w*, is brought into contact with the paper slip or riband, R, and records there a line which is longer or shorter as the attraction of the armature is longer or shorter. Such an arrangement is known technically as an ink-writer, an ink-writing Morse, or Digney telegraphic apparatus.

For the purpose of easily maintaining long or short contacts, an instrument termed a *key* is employed. The simplest form of key is shown in Fig. 10. This kind of key, known technically as a *single current key*, consists principally of a horizontal bar centred upon a fulcrum. At and above one end of the bar is a knob or handle. Beneath the knob is a small projection which can be brought into contact with another projection upon the stand of the instrument. To the latter projection is attached a wire, B, from one pole of the battery. The line wire, L, is attached to the fulcrum of the bar. At the back of the bar is another projection both on key and stand, and these projections are kept in contact by a spring (not shown in the engraving). To the projection at the back of the stand (technically termed the 'back stop,' the projection under the knob being the 'front stop') is attached a wire, I, leading to the electro-magnet coils of the ink-writer. Of course these wires are not permanently so attached, but actually are inserted in three binding screws at the back of the stand, wires being brought under the stand to the stops, as shown in the subjoined plan (Fig. 11).

FIG. 10.

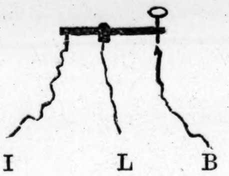
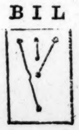
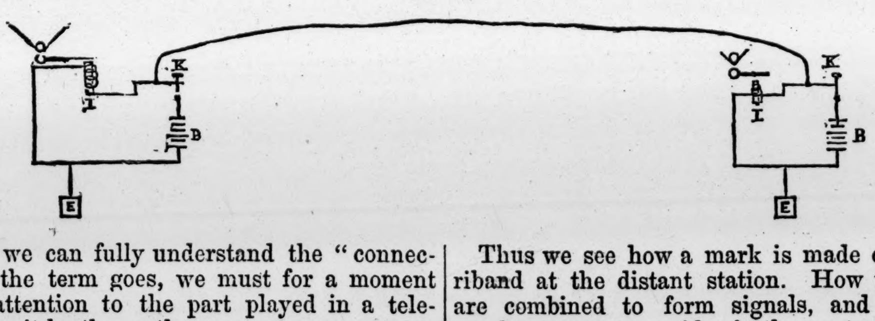


FIG. 11.



The method of connecting the instruments, or ink-writers, between two stations is very simple; but before we can fully understand the "connections," as the term goes, we must for a moment turn our attention to the part played in a telegraphic circuit by the earth.

FIG. 12.



Steinheil, in 1837, was the first to employ the earth as a substitute in a telegraphic circuit for the return wire. He buried two copper plates in moist earth, one at each station, and connecting the extremities of his telegraphic lines to these plates, and found that signals could be transmitted with as much facility as when a return wire was used. In fact, as proved by Wheatstone in 1841, the same battery will work to a far greater distance with a circuit half wire and half earth than when altogether wire. In 1844, Matteucci, by an experiment in which he caused the current from a single Bunsen cell to flow through a copper wire 9281 feet in length, and through the same length of moist earth, found that the earth conducted so much better than the wire that its resistance must be regarded as nothing. Bréguet also found on the telegraph line between Paris and Rouen, that when the current traversed a circuit half metal and half earth, the intensity was twice as great as when the circuit was metallic throughout.

Two explanations * have been given of this non-resistance of the earth; one, that as the conducting power increases in proportion to the area of a section of the conductor, the earth acting as a conductor of infinite area, offers a smaller amount of resistance than the metallic part of the circuit; the other, that the earth acts as an immense reservoir, which absorbs all the electricity poured into it. We need not now, however, stop to ascertain the reason why; we shall do better to proceed to the question of communication between two stations.

Having buried at each station † a large copper plate (if there be no gas pipe or water pipe of large surface), we connect, as in the diagram (Fig 12), one pole of our battery to this plate, and the other pole of the battery to the front stop of the key K. Our line wire we connect to the fulcrum at the centre of the key, and from the back stop we carry a piece of wire to one end of the electro-magnet coils of the ink-writer, the other end of these coils being connected to the earth-plate.

Now when one station depresses its key, the circuit is completed through the battery, front stop of key, line wire at middle of key (the current cannot pass by back stop to earth, because when the key is depressed the key and back stop are necessarily separated), to middle of key at distant station, through back stop of that key, (the current cannot pass here by the front stop because it is drawn down upon the back stop by a spring), the coils of the receiving instrument (magnetising them, attracting the armature, and marking the paper), and thence passes to earth, where it is absorbed or carried again to the distant plate.

Thus we see how a mark is made on the paper riband at the distant station. How these marks are combined to form signals, and the signals words, we must consider in the next paper.

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* See Pynchon's Chemical Physics, page 400. Van Nostrand and Co., New York.

† What we do at our station must be repeated at the distant one.

Proceedings of Societies.

ROYAL SOCIETY.

The Croonian Lecture was delivered by Benjamin W. Richardson, M.A., M.D., F.R.S., "*On Muscular Irritability after Systemic Death.*" The object of the lecture was to put forward certain facts the author had learned on the phenomenon of muscular irritability after systematic death. He included in the same study certain examples in which muscular irritability has for a time ceased, but has become re-developed under new conditions. He thus included the study of those states which favour the continuance of irritability or which destroy it and those conditions which suspend it but do not destroy it. By this method of research the author thinks we may proceed backwards towards living irritability, and may determine upon what that depends with more facility than by experimenting on the phenomena of irritability in the living animal. He imagines that if he knew nothing of the construction of a watch, or why for a certain time a watch maintains its motion, and if he had nobody to teach him these things, he might be better able to arrive at the fact he wanted by trying to set the motionless watch into motion than by interfering with it while it is in motion.

The record of experimental endeavour carried out with the design above explained, included a review of the work of twenty-five years. The subjects brought under consideration were arranged as follows:—

(1). The effect of cold on muscular irritability after systemic death.

(2). The effect of motor forces, mechanical, calorific, electrical.

(3). The effect of abstracting and supplying blood.

(4). The effect of certain chemical agents, organic and inorganic.

The effect of electrical excitation is in the same direction, but is varied according to the mode in which the excitation is performed. Discharge from the Leyden jar produces contraction, which is permanent or intermittent in accordance with the mass of the muscle and the intensity of the discharge. This fact was elucidated by reference to a series of experiments with a Leyden battery, placed in cascade, and the effect produced by the discharge from 96 feet of surface upon animals of different sizes and weights, from sheep down to pigeons, as well as on sections of the bodies of the same animals immediately after death. The experimental facts demonstrated that with an efficient discharge the whole muscular system of a small animal could be fixed instantly in the rigidity of death, and that the precise position of the animal at the period immediately preceding death was retained with such perfection, so sudden was the change, that nothing but physical examination by the hand could bring to the mind the fact that the animal had passed from life into death.

But the same shock passed through a sheep weighing 54 pounds produced only a temporary contraction of muscle, and required repetition before the rigidity was rendered permanent.

By employing discharges of less tension it was found that muscles, or special tracts of muscles, in the same animal immediately after its death, could be made rigid quickly or slowly by variation of the intensity of the discharge.

The effect of the intermittent electro-magnetic current was next brought forward, and was shown to resemble closely that of the simple electrical discharge from the Leyden phial.

Intensified it induces permanent contraction; and if it be repeated even with low tension, so as to call forth contraction, it destroys the irritability, *cæteris paribus*, more quickly than if the muscle had been left to itself.

Parenthetically, the lecturer dwelt here on the common practice, after sudden death, of endeavouring to excite the action of the enfeebled heart by passing through it an electrical current. Some practitioners, said the author, have gone so far as to introduce a needle into the heart itself, and to make the needle act as one of the conductors from a battery. Such experimentalists, before they undertake this operation on the human subject, should at least observe the effect of the agency they are employing on the exposed heart of an inferior animal recently and suddenly killed by drowning or by a narcotic vapour. They would learn then with what infinite facility the muscular irritability of the heart, in all its parts, is excited for a moment only to be permanently destroyed. They would learn that if blood be not passing through the muscular structure concurrently with their exciting current, they could not more effectually arrest function than by the very method they have adopted to sustain it.

The influence of the continuous current on muscular irritability was introduced by the author, together with a special reference to the first experiments of Aldini on the bodies of malefactors who had been recently executed; and it was shown from Aldini's most noted experiment how largely the phenomena of motion he induced in a dead man, and the recital of which caused so much sensation in the year 1803, was due, not to the galvanism, but to the circumstance that the dead body had been exposed for the hour after death and before the experiments commenced, to the action of cold 2° below freezing-point. On the whole the continuous current acts on muscular fibre after the manner of heat. If the muscle, recently dead, be exposed to cold, the current, when sufficient, restores for a limited period the irritability, and finally destroys it by inducing persistent contraction. If the muscle, recently dead, be left at its natural temperature, the current simply shortens the period of irritability by quickening contraction.

PARIS FACULTIES OF SCIENCE.

"*Electrostatic Phenomena in Batteries.*"—(M. Branly's Thesis for the Doctorate).

The poles of batteries and circuits traversed by currents present very feeble charges of static electricity. The study has been commenced by Biot and Kohlrausch; M. Branly pursues the same subject.

On a metallic conductor, insulated and charged with frictional electricity, we may, with the aid of a proof-plane and a Coulomb's balance, determine the relation of electrical densities at the different points of the conductor. If we join any point of the conductor to the fixed ball of the balance by a long fine wire, we have an independent indication from the point of contact, and proportional to the total charge; the interior *potential* of the conductor is the same as that of the fixed ball, and is represented by $\frac{q}{r}$, r being the radius of the ball, and q the quantity of fixed electricity on it; the amount of q is found by the repulsion exercised on the movable ball.

This given, we will consider an isolated pile, having one of its poles, the negative for example, joined to the earth; we may verify that in this case, the positive pole is similar to a conductor charged with electricity by a constant frictional machine; the electrical distribution is not uniform, but the tension or interior potential is constant. The direct determination by the balance of the potential of the pole of a battery permits us to employ batteries as sources of static electricity having an estimated value in absolute units, and presenting under this head great interest.

The experiment has been made with elements of zinc, copper, and water, and also with elements of zinc, platinum, and water. The positive pole of a battery of 200 elements was joined to the movable ball by the torsion wire and to the fixed ball by a fine metallic wire. The two balls are placed at a certain distance without any torsion in the wire; the communication with the battery once established, they present the same potential as the pole of the battery under consideration, and their deflection increases in proportion as the torsion of the wire tends to equilibrate their mutual repulsion; the displacement of the movable ball and the angle of torsion being taken by means of a mirror fixed in the prolongation of the wire and by a divided scale.

The charge q of the two balls is given by the formula—

$$\frac{q^2 \cos \frac{a}{2}}{4 r^2 \sin^2 \frac{a}{2}} = n\, t,$$

where a is the angle of deflection, r the radius of the circle described by the movable ball, t the angle of torsion of the given wire in seconds, and n the moment of the couple of torsion necessary to twist the wire through the angle of 1″. Let ρ be the radius of the balls, $\frac{q}{\rho}$ is their potential or that of the pole of the battery. The unit of electricity adopted is that which, concentrated at a point, exercises on an equal quantity, concentrated at a distance of 1 millimetre, the same action that a unit of force exerts on a mass of 1 milligramme (the weight of a milligramme at Paris is 9808 units of force). With these units the potential of the positive pole of an element of zinc, copper, and water, of which the negative is joined to the earth, is equal to 3·26.

In the mirror balance constructed by Hankel, four fixed balls sustained by rods of brass are placed at the apex of a rectangle; a metallic needle sustained by a steel wire carries two other balls at its extremities. Two fixed balls placed on the same diagonal are joined to one of the poles of a Volta's pile, the two other fixed balls are joined to the other pole of the same pile. It follows that if we charge the movable needle, it acts in the same manner as the gold leaves of Bohnenberger's electroscope. A mirror soldered to the torsion wire serves to mark the deflection and the torsion. If we substitute plates for the four balls, the sensibility is increased; this arrangement has been adopted by Sir W. Thomson. M. Branly has adopted Sir W. Thomson's apparatus in the arrangement of the sectors; the new electrometer which he has constructed composed of a small number of pieces, is easily constructed and very simple to manage.

A metallic plate of large surface, in the form of the figure eight, is suspended horizontally over the four sectors forming the quadrants of the same circle and joined diagonally two to two, the centre of the plate and that of the circle being in the same vertical line; the plate is sustained by a metallic wire which communicates with the pole of a pile, and receives from it a permanent electrical charge. Suppose we have to measure the difference of potential between two points, A and B; A is joined to two opposite sectors which take the same potential as A, and B to the two other sectors which take the same potential as B. The plate being attracted by one of the couples and repelled by the other, there is at a certain angle of deflection equilibrium between the electric action and the force of torsion of the wire. In working with it feeble deviations are rendered measurable by a mirror fixed on the prolongation of the torsion wire, the distance of the different points of the plate from the sectors varies little, and the action exercised by the two couples of sectors is proportional to the product of the difference of their charges or of their potentials by the charge of the plate. It may be experimentally proved that the indications of the electrometer are proportional to those of Coulomb's balance. It is necessary, for this verification, to diminish the sensibility of the apparatus, which is easily done by changing the torsion wire, by elevating or lowering the plate, by varying its charge.

The difference of potential at the two poles of a battery, of which the circuit is open, being proportional to the electromotive force, that is to say, to the intensities that have the same resistance, the measure of the electromotive forces, the study of their variations, and the laws to which they are subjected, is easily effected with the aid of a mirror galvanometer. This mode of determination is advantageous on account of its rapidity, especially in the case of elements of a single liquid, and the polarisation is no obstacle, since the element remains open.

In the circuit of a battery, we may regard the current as resulting from the difference of potential which exists between the two poles, and, whilst the battery works each of the parts of the interpolar circuit may be compared to a conductor charged with static electricity and possessing a determined potential, different from that of the neighbouring parts, and remaining constant as long as the current is constant. Generally, the difference of potential between two points being proportional to the intermediate resistance, we are able to study directly, without modifying the circuit in any way, the relation of the resistances of metallic wires and of different parts of the same wire.

In a complex circuit formed of the element and the conductor which unites the two poles, the difference of potential is distributed proportionally to the resistance, and the sum of the differences is equal to the difference obtained at the two poles of the open element. It follows that, in order to have sufficient sensibility in the case of feeble resistances, we must increase the dimensions and the conductibility of the battery which produces the currents.

Galvanometric measures are comparable with those of the electrometer; this has been verified by numerous observations. The intensities obtained with a tangent galvanometer or a voltameter placed in the circuit may be represented by the difference of potential $a - b$ observed at the same time at the two extremities of a constant resistance, r; for example, 100 metres of Pouillet's mercury unit, which may be expressed by the formula—

$$i = k\,\frac{a-b}{r}.$$

It is easy to comprehend that the same reading made on the electrometer furnishes also a measure of the total resistance of the circuit; we will represent by 800 the difference of potential at the two poles of the open battery, and we will represent the difference observed at the extremities of the bobbin, which is equal to 100 metres of mercury, by 146, the total resistance of the circuit will then be $\frac{800}{146} \times 100$ metres.

We therefore think that the electrometer may be employed for measuring the intensities of currents. We may take for the unit of intensity the intensity of a current which is produced at the extremities of a wire of which the resistance is 100 metres of mercury, a difference equal to one hundredth of that which exists between the two poles of a Daniell's element. The intensities obtained at different times would always be comparable, and may easily be, if wished, converted into Weber's absolute units. A comparative measure, made with an electrometer and with a galvanometer, will determine the coefficient by which the indications of the latter should be multiplied in order to represent the intensities with the adopted units.

CONGRESS OF GERMAN NATURALISTS.

The meeting of this important body of scientific men, recently held at Leipsig, was attended with the greatest success financially, and in historical record. The papers on electrical subjects were not numerous, being included chiefly by that of M. Hankel on the thermo-electric phenomena of crystals. It is generally considered that crystals of two axes are alone capable of producing pyro-electricity. This opinion is inexact. Pyro-electricity obtains with all crystals when other physical causes do not intervene, even to a degree measurable by the electrometer. Messrs. Witner, Sohncke, and Œttingen made some remarks upon this subject. M. Weber spoke of a normal standard for the measure of galvanic phenomena.

VIENNA IMPERIAL ACADEMY OF SCIENCE.

Professor A. de Waltenhofen has established by the aid of the calculus the following theorem:—The magnetising power of a spiral is proportional to the product of the intensity of the current multiplied by the sum of the cosines of all the angles formed by the axis of the magnetised coil and the right lines directed towards the extreme points of this axis from a point on each turn of the spiral, situated in the plane of the axial section. This theorem is available only in the supposition that the axis of the magnetic coil is in the same direction as that of the helix, and that the intensity of the current does not exceed limits within which it remains proportional to the electro-magnetic force. This theorem confirms and explains the results of the experiments of MM. Lenz and Jacobi on the relations between the electro-magnetic power, and the number, amplitude, and arrangement of the turns of the metallic wire. The construction proposed by M. Haédenkamp for the attractive action, and that proprosed by M. Wazsmuth for the magnetising action of a spiral, are both only particular applications of the theorem of Waltenhofen. The sum of the cosines of a cylindrical spiral, calculated according to this theorem, serve to determine the relation between the magnetising power of two given spirals, and here again the results of calculation coincide with those of experiment.

MM. Boltzmann and Romich have proceeded with their experimental researchés on dielectric constants of insulating bodies, using for this purpose an electro-magnetic diapason, the oscillations of which charged at short intervals alternately with positive and negative electricity, the conducting ball of which they wished to find precisely the action on the dielectric ball. They have been able also to eliminate that disturbing cause termed by Faraday electric absorption, and to obtain constants sufficiently concordant with those deduced from experiments with the condenser, as the following comparative table shows:—

Dielectric Constants.

Substances.	By the mutual action of the balls.		By the Condenser.
Sulphur	3·857	3·904	3·84
Hard Gum	3·550	3·400	3·15
Paraffine	2·310	2·280	2·32
Colophane	2·450	2·470	2·55

Sir Charles Wheatstone has been elected Foreign Associate of the Paris Academy of Sciences.

Telegraph from Heligoland to Hamburg.—On the 7th inst. the telegraph line from Heligoland to Hamburg, constructed by the United German Telegraph Company of Berlin, was opened for use by the despatch of a message from Lieutenant-Colonel Maxse, Governor of Heligoland, to the directors of the company.

Electrical Science in Foreign Journals.

(We intend to devote this column to a list of Electrical Memoirs published in Foreign Journals during the month. Those of importance will be either translated in full or given in abstract.)

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, Vol. lxxvi., No. 22.

Action of the Electric Fluid on Flames, Liquids, and Substances in Powder.—By M. Neyreneuf.—The Bunsen flame is not repelled by a negative point. It is interesting to prove the effects produced on flames not containing solid particles. With pure hydrogen there is no repulsion, but very sensible attraction to a negative point. With carbonic oxide agitation only was produced with the two electricities; the attractive effect is, however, still marked. The experiment is important, for the flame of this gas contains no solid particles, and there is no water formed during combustion. Sulphide of carbon gives the same result as carbonic oxide. Alcohol acts very like coal-gas. But repulsion is greatest with turpentine burned in a lamp like alcohol. If we direct the point normally to the surface of a liquid contained in a conducting cylindrical capsule, a cord is produced by the two electric fluids with water, oil, sulphide of carbon, and turpentine. If the point is in contact with the liquid, we observe no alteration on the surface. With bad conducting liquids, if we withdraw the point to a distance of some millimetres, we raise a cone of the liquid, which adheres during the whole time the current passes. No difference accrues with change in the direction of the electricity. Few powdered bodies admit of obtaining clear results. Organic powders (lycopodium, liquorice, rhubarb, &c.) manifest adherences specially studied by A. Kundt, and of which we are here unable to treat. Blue sand is the substance which acts the best.

No. 23.

On the Multiple Causes that Provoke the Discharge of Lightning.—By M. W. de Fonvielle.—Having rapidly enumerated the causes relating to the form, nature, and situation of the objects struck, M. Fonvielle seeks to show that two neighbouring conductors react strongly one upon the other when they are under the influence of a storm-cloud. He seeks to establish that this reciprocal influence is not the same in the case where the two conductors are insulated, or when they are placed in connection with the common reservoir, either the one and the other, or the one or the other only. It is known that an electrified cloud acts by induction on all the objects which it covers, but, as M. Fonvielle believes, no one has yet remarked that by the fact of its movement the electrified cloud produces special reactions. According to him, it acts in the same manner as the revolving plate of a Holtz machine, which by its movement at a distance from an induced body, produces, as we know, an energetic disengagement of electricity. M. Fonvielle seeks to draw some practical conclusions from this assimilation, which appears to him to explain how it is that insulated conductors, placed to the south-west or north-east of considerable masses with a common reservoir, are more frequently struck. He hopes to arrive ultimately at experimental proof of all these theoretical deductions, by the aid of a special register for condensing lightning conductors, of which he has already had the honour of laying a notice before the Academy at the commencement of January last. M. Fonvielle enumerates certain phenomena, such as the rise of the sea, which seem to show that the attraction of the clouds is powerful enough to make itself perceived on the surface of the earth. It appears to him necessary to conclude from this, reciprocally, that the influence of the surface is sometimes powerful enough to modify the pace of the clouds, so as to impart to them in certain cases a greater velocity before they reach the zenith of the object influenced. Changing greatly their character, these attractions can, in other circumstances and particularly until there is no electric discharge, diminish the velocity of the clouds after they have passed the zenith of the electrified object. In short, these attractions and repulsions, of which we have too long neglected to take account, place themselves in juxtaposition to the movements produced by the primitive Newtonian attraction and repulsion as the displacement of the clouds are combined with the general action of the wind. M. Fonvielle concludes by remarking that the modifications stated in the value of the terrestrial magnetism, consequent upon the movement of the stars, are analogous to those which the clouds produce on the electrification of points of the earth's surface. In all the cases, the electric forces developed incontestably proceed from the transformation of dynamic efforts, be the motor the wind or any known or unknown cause of movement.

Relation between Electric and Capillary Phenomena.—By M. G. Lippmann.—(1). The surface of a drop of mercury placed in a glass vessel and surrounded with diluted sulphuric acid, quickly contracts, becoming more convex when placed in metallic communication with a point of iron or copper which touches the acidulated liquid. It then produces an electric current which polarises the surface of the mercury. The experiment shows, first, that the contraction of the surface is due to a change in the capillary constant, this constant and the electromotive force of polarisation being continuous functions of one another; second, that, reciprocally, an extension of the surface produced by a purely mechanical action polarises it in the same manner as an electric current. (2.) Variation of the capillary constant of a surface of mercury polarised by hydrogen. The method employed consisted in polarising the top of a column of mercury contained in a glass tube by the current of a Daniell's element. The value of the capillary constant was taken by measuring the depression produced by the meniscus. The same arrangement which furnished the current was used to measure the electromotive force of the polarisation, by the method of opposition. The results have been constant and concordant. The capillary constant varies from 30·4 to 41·3 milligrammes, when the electromotive force of the polarisation varies from zero to 1° Daniell. In employing a glass tube drawn to a slender point, of a diameter of about 0·02 m.m., placed under the objective of a microscope, we obtain a *capillary electrometer* of great sensibility, well adapted to measure electromotive forces. The free tension at the poles of a Daniell element is measured by a pressure of more than one-third of an atmosphere. The approach of a feebly-charged proof plane produces, by influence, a current which repels the meniscus. (3). Polarisation produced by a variation of the surface.—By replacing the pile either by a Thomson electrometer as modified by M. Kirchhoff, or by a galvanometer, and displacing mechanically the column of mercury, we find that the capillary constant of the surface and its electromotive force vary continuously whilst the surface is developing. The quantity of electricity produced may be measured in absolute value; it is independent of the form of the surface, and is simply proportional to the increase of area. These quantities change their sign when the surface diminishes instead of increases. (4.) Electro-capillary motive machine.—We are able to construct, by the principles given above, a motor which transforms indefinitely the current of the battery to mechanical work. Two masses of mercury, surrounded by sulphuric acid, may serve alternately for negative electrodes to the current of a Daniell's element. In each mass is partially immersed a bundle of glass tubes, open at both ends. At each inversion of the current one of the bundles ascends, the other descends. A system of levers transforms this alternate motion into rotary movement. The machine itself works its commutator. When we replace the battery by a galvanometer, and then work the fly-wheel of the machine by hand, the needle is deflected during the rotation and in a direction which changes with that of the rotation.

Revista de Telegrafos, June 1, 1873.

Acoustical Telegraph.—By Don Naranjo y Garza.—This is an account of an acoustical telegraph put in operation during the siege of Paris, and there are detailed besides some interesting experiments with regard to the velocity of sound.

Revue Hebdomadaire de Chimie, Vol. iv., No. 22.

New Method of Firing Mines, Dynamite, &c.—By M. Toselli.—The principle by which M. Toselli proposes to supersede the present method of firing mines by electricity, is the transmission of pressure in a liquid. The inventor employs a metallic tube of about one centimetre in diameter laid from the firing station to the mine. At one of its extremities, the tube is in connection with a very feeble pressure pump, and at the other is fitted with a piston which is attached to the trigger of a pistol or to a fuse. By the slight motion caused by pressure of the water, the trigger is moved, and sets fire to the powder or other explosive material.

On Military Telegraphy.—A review of a brochure of 132 pages, from the pen of Lieutenant Auréle Guérin, the work itself advocating adherence to the Prussian system.

Electric Apparatus.—By Messrs. Boulay and Co.—A description of the ordinary trembler bell combined with a new form of battery which is not detailed.

The Telegrapher, May 31, 1873.

New Automatic Type Printing Telegraph.—The system may be described as a combination of the Little and the Bonelli apparatus. The machine by means of which the transmitting strip is prepared consists of twenty-five cylindrical steel punches, one-sixteenth of an inch in diameter and the same distance apart, arranged to form a square of five rows each way. A key board, analogous to that of the House printer, is so arranged in connection with the punches, that when any particular key is depressed the proper punches for forming the corresponding Roman letter are selected and forced through the paper slip, perforating the paper with apertures arranged in the form of the letter. The letters, as perforated in the transmitting slip, are half an inch in height. The strip, after having been thus prepared, is passed at a rapid rate through a transmitter similar to that of the Little automatic, but provided with five circuit closers, side by side, corresponding precisely to the five horizontal ranges of punched apertures from which the letters are formed. A corresponding receiving instrument, running at an approximate speed, is provided with five pens or styles, arranged in a row transversely across the chemically prepared strip, which is made to pass beneath them. The Roman letters, as recorded upon this strip, are much smaller, and appear far more legible than upon the transmitting strip. Five line wires are, of course, required to work it, although it is considered possible to be able to do the work with one. With five circuits the rate of speed with which messages may be recorded in plain Roman letters is from four to six hundred words per minute for the permanent printing, with an iron solution, and twelve to fifteen hundred words per minute with the fugitive iodine solution.

On the Proper Resistance of Relay Magnets.—By C. H. Haskins.—I have waited patiently for a brief practical article on the proper resistance of relay magnets, as compared with the lines on which they are used. The profession is still divided, to a considerable extent, on the question of "high" and "low" resistance of relays. As usual, the truth lies between the two extremes. Both parties are right and both wrong. The law is laid down in various works, plainly and positively, and it is this: "When the combined resistance of the instruments in circuit is equal to the resistance of the line wire, the magnetic force is a maximum." In other words, when the resistance of all the relays in circuit is equal to the resistance of the line wire, the best effect is obtained. And I will add, that experience has shown that, in apportioning battery to a line proportioned practically as above, the number of cells of Grove or carbon battery to be used may be found by dividing the combined resistance of the relays and line wire by 100; for any form of sulphate of copper battery, by 50. *Example:* A line of No. 9 wire, of 200 miles long, measures say 20 units per mile. We have 25 offices on it.

200 miles at 20 units, = 4000
$\frac{4000}{25}$ = 160 units per each relay, = 4000

Total resistance, = 8000

To work it you will require 80 cups of Grove or bichromate, or 160 cups of Daniell, Hill, or Callaud battery. This arrangement will give, even with glass insulation, a fair working line in bad weather, although not as good as better insulators would make. The selection of the size of wire that should be used for the helices need not be discussed here, as any intelligent instrument maker should be able to determine this—the magnetic effect produced with a stated resistance, and a given current being determined by the number of convolutions. The anxiety of operators to have "sensitive" relays, and the recklessness of some manufacturers in furnishing high resistance relays to meet this demand, has rendered many otherwise good lines almost worthless in bad weather. Because a line is worked on the margin or difference between the added resistance of the line and instruments on the one hand, and the insulator resistance on the other, if, in any way, you lessen that margin or difference, you injure the working of the line. To make this plain, let us suppose a case. You introduce on a fair working line a relay of very high resistance compared with the others in circuit. It works with great ease when the others will not. The superintendent does not reason upon it, or he would know at once that he has made all the other relays work worse by introducing this one. He is filled with admiration that this new relay should be so "sensitive." The others are condemned, and the line stocked with the new "sensitive" pattern. But when this has been done, he discovers that he has not enough main battery, for the amount of current flowing to line is decreased by the increased resistance in the circuit. Not understanding why it is, he ascribes it to bad connections—bad wire, the weather,—everything but the real cause, and increases battery accordingly, until he has a "snapping circuit." All goes on pretty well until he gets a few days of soaking wet weather, when his line leaks at every insulator. Its effectiveness is gone; it is only a "dry weather" line. This is not a fancy sketch; it is the history of dozens of lines throughout the country. And the *rationale* is this:—The first "sensitive" relay introduced made the others work worse, the rest were all replaced by high resistance ones, the resistance of the circuit was thus increased, the margin or difference between line and insulator resistance, on which the line is worked, was diminished, and the amount of current, although more was needed to overcome the increased resistance, was actually lessened. Now, an increase in the number of cells of a battery means an increase of electro-motive force or energy—*an increased power-overcoming resistance, not only of the line and relays but of the insulators also!* Consequently, the line which, with relays properly proportioned to its wire resistance, worked with a small battery, whose current was of such low force or energy as not to escape to any considerable extent over the wet surface of the insulators to the ground, now that the high resistance relays have made more battery necessary, leaks like a sieve at every pole in wet weather. The cries for "high" or "low" resistance relays are senseless, because they are mere individual opinions, unsupported by reason. The law given above is subject to some modifications, on very long circuits, for instance, with only two or three relays; but its application to lines generally would save time, temper, and battery, and make many lines work clear in bad weather that are now loaded down with unnecessary resistance, and work badly as the result.

June 21st, 1873.

Condenser for the Little Automatic Telegraph.—In order to use a chemical telegraph in connection with electro-magnets in the circuit, it is requisite that a condenser should be used in connection therewith. After much experiment to obtain the best form of condenser, Mr. George Little, consulting electrician to the Automatic Telegraph Company, informs us that the condenser he prefers to use with the electro-magnets, in order to avoid or lessen the disturbing influences of extra currents, &c., is a modification of M. Planté's liquid condenser, and consists of two thin leaden plates, of about ten inches square surface, between which is a thick piece of flannel, saturated with glycerine, so adjusted as to offer about seven times more resistance than that represented by the helices of each electro-magnet, the whole being enclosed in a strong flat mahogany box, and hermetically sealed with paraffin.

American Journal of Science, Vol. v., No. 29.

Induced Currents and Derived Circuits.—By John Trowbridge.—The expression for the intensity of an induced current, deduced by Neumann and Sir William Thomson, is as follows:—

$$i = \frac{1}{k} \frac{d\,U}{d\,t},$$

in which k is a coefficient depending upon the resistance of the complete wire in the secondary circuit, and U is a certain "force function" which depends solely upon the form and position of the wire at any instant, and on the magnetism of the influencing body. The expression, in general language, is as follows:—"When a current is induced in a closed wire by a magnet in relative motion, the intensity of the current produced is proportional to the actual rate of variation of the "force function," by the differential coefficients of which the mutual action between the magnet and the wire would be represented if the intensity of the current in the wire were unity." This investigation was undertaken to ascertain if the laws of derived circuits apply to the currents of induction, which are represented by equations of which the above is a type. A reflecting galvanometer of large resistance was included in the secondary circuit, and connected by copper wires of very small resistance with the coil in which the secondary currents were produced; the resistance of these wires was infinitesimal in comparison with the resistance of the galvanometer. The galvanometer was then shunted. The results show that with an inappreciable resistance outside the galvanometer the shunts made no difference in the deflection of the galvanometer needle when the shunts were not less than three ohms. Below this the current divided. The experimental numbers show that an equal impulse was transmitted through both the shunt and the galvanometer; for no reason can be assigned why it should take one course in preference to the other. Two galvanometers, therefore, of the same resistance, one forming the shunt to the other, will give the same deflection, which is equal to that given by the undivided circuit. Resistances, were then introduced in the circuit exterior to the galvanometer coils (of 588 ohms), and a shunt of 5880 ohms was used. No effect was produced by the shunt until the exterior resistance was appreciable in comparison with that of the galvanometer. With large resistances exterior to the galvanometer resistance, and appreciable in connection with it, the laws of the division of currents practically hold, and as the exterior resistance approaches that of the galvanometer, the coincidence with the laws is more marked. It appears that, under certain conditions, an induced current does not divide according to the laws of divided circuits, but approximates to these laws when there is a resistance exterior to the galvanometer which is appreciable in comparison with that of the galvanometer.

On Methods of Determining the Resistance of a Battery, Deduced from Poggendorff's Mode of Measuring Electro-Motive Forces.—By N. D. C. Hodges.—In the process of obtaining the ratio between the electromotive forces of two cells, the expression—

$$\frac{E'}{E} = \frac{B+R_0}{R_0}$$

is obtained; in which $E > E'$, R_0 is the resistance necessary to bring the needle of the galvanometer G to zero, and B is the resistance of the battery to be measured. By introducing a new resistance R′ in the branch *a b*, we shall obtain the expression—

$$\frac{E}{E'} = \frac{B+R'+R_0+R_1}{R_0+R_1},$$

in which R_1 is the new value of R_0; hence—

$$\frac{R_1}{R'+R_1} = \frac{R_0}{R+R_0} \text{ and } B = \frac{R_0R'}{R_1}.$$

If the ratio $\frac{E}{E'}$ becomes $\frac{m}{n}$ we shall have—

$$\frac{m}{n} = \frac{B+R_0}{R_0} \text{ or } B = R_0 \left\{\frac{m}{n} - 1\right\}.$$

This expression was given by Mr. Mance in the *Phil. Mag.*, vol. xli., p. 318, 1871, and is seen to follow directly from Poggendorff's method of measuring electromotive forces. The following are the results obtained from the expression

$$B = \frac{R_0R'}{R_1},$$

in measuring the resistance of two Grove cells. One Grove cell was opposed to the two whose combined resistance was measured:—

R_0	R′	R_1	B.
357	1	1·028	0·347
,,	2	2·057	0·347
,,	5	5·144	0·347
,,	7	7·140	0·350

By Mr. Mance's method, with the same value of R_0, the value obtained was $B = 0{\cdot}357$. The above numbers are expressed in ohms and fractions of an ohm. My method has the advantage that many determinations of the battery resistance can be made with the same arrangement of cells. In Mr. Mance's method but one determination can be made without altering the arrangement. I have found the following form of Rheocord useful in these determinations. Let *a* and *c* be two German silver wires, with a slider at *d* provided with a binding screw; between the wires is a mirror, *b*, with a scale upon it or at its side, in order to avoid parallax in reading. Let Oρ be a German silver wire or rod of small resistance, and connected to one end of the wire *c*. Supposing the slider to be arranged near the centre of the two wires, the current coming in at one end *n* of the wire *a* will divide at *d*, pursuing the two paths $d\,\chi\,\rho$ and $d\,m\,o\,\rho$, that is, through the wire χ which connects the slider with the free end of the German silver rod $o\,\rho$, and through part of the wire *c* and the German silver rod, which is connected to *c* at *m*. By placing a box of resistance coils in χ, we can make the combined resistance of $d\,\chi\,\rho$ and $d\,m\,o\,\rho$ differ as little as we please from the standard resistance $o\,\rho$. It is thus possible, by making a large variation in χ, to measure small resistances a little larger than the resistance $o\,\rho$, thus employing the correct principle of working from the greater to the less. By disconnecting the resistance $o\,\rho$ at *m* and ρ, and joining *m n*, it will be readily seen that the combined resistance of the circuit *d n m d* is one half that of *n d* alone. It is often desirable to reduce the resistance in this manner. The changes in the combined resistances can of course be readily calculated from the expression—

$$\frac{\chi\eta}{\chi+\eta} = R,$$

where χ and η represent the two branches of this circuit. I have often found it advantageous in measuring large resistances to shunt them, so to speak, in the Wheatstone's balance, thus forming a combined resistance, one branch of which includes the large resistance, and the other a carefully measured resistance much smaller than the resistance to be measured; the balance can in this manner be kept in its most sensitive arrangement, and a series of measurements can be made of the large resistance by varying the carefully measured portion of the combined resistance.

On a Method of Measuring Induced Currents.—By F. H. Bigelow.—This paper will appear in our next.

Revue Scientifique de Florence. May, 1873.

Is the Electric Current an Ether Current?—By Professor Antoine Bolti.—The professor concludes that if the electric current is an etherial flux, the velocity of this ether should be slow. Admitting the velocity of light to be 208,000 kilometres per second, the length of a wave 0·005 millimetre, the velocity of a current would be less than 800 metres.

Professor Belli on Electric Condensers.—By Professor Jean Cantoni.—A controversy, personal rather than practical.

Bulletin de la Societe d'Encouragement pour l'Industrie Nationale. May, 1873.

Prize (3000 francs) for Economic Art. Report by Count du Moncel upon Gramme's Machine.—This machine, for which the prize has been awarded, is highly commended by the Reporter. The report includes an abridged history of magneto-electricity, not, however, suitable for abstracting.

Bichromate of Potash Batteries.—By MM. Voisin and Dronnier.—(Bronze medal). The vast application of bichromate of potash batteries has led us to seek for, amongst the improvements of which it has been the object, some means of avoiding the inconvenience resulting from the employment of a liquid prepared in determined proportions and always difficult to make.

M. Chutaux has, for this purpose, attempted to obtain a solid salt of acidulated bichromate of such a kind that, in order to prepare the exciting liquid, it is only necessary to put into water a sufficient quantity of the salt as to be in excess in the solution. But this product, not being constituted in the required conditions in order to furnish a true chemical compound, has only produced inferior results to those which are obtained with acid solutions. It is this question which MM. Voisin and Dronnier have renewed. In treating with the chemical equivalents, and in combining the products entering into the composition of their exciting liquid (sulphate of sodium, sulphuric acid, and bichromate of potash), in such a manner as will completely utilise the oxygen of the chromic acid, they have arrived at very satisfactory results. It is computed from numerous experiments that the sand batteries of M. Chutaux, at the end of a month's service, develop an electromotive force greater with the saline solution of MM. Voisin and Dronnier than with the solution of acidulated bichromate, which is, however, richer in bichromate than in sulphuric acid. At the same time the constancy of it is greater, especially when the liquid of the battery is not very well kept up, and we find in this liquid a greater homogeneity of composition. On account of the advantages obtained by MM. Voision and Dronnier, the Society have awarded them a bronze medal.

Vol. xx., No. 247.

Report by M. du Moncel on M. Mayer's Autographic Telegraph.—A description has appeared already in these pages.

Les Mondes. Vol. xxxi., No. 8.

Magnetic Phenomena.—By M. Ruhmkorff.—I have been led to the following experiment in constructing a Romilly machine. Physical theories state that from the moment when a circuit is approached by one of the poles of a magnet the current flows in the same direction as when the opposite pole is withdrawn. This is the case if we employ a circuit at a distance from the magnet, but if we make the experiment with a bobbin sliding on a bar, the effect is no longer similar; for, if I slide a bobbin on to a bar magnet from either extremity to the centre, then from the centre to the other extremity, the deflection is opposite for each portion of the bar traversed.

Scientific American, Vol. xxviii., No. 18.

Foul Air Signal.—The gas which leaks through stoves and furnaces, and arises from imperfect combustion, known as carbonic oxide, can be absorbed in a way to betray its presence by the following ingenious invention:—The apparatus consists of a small galvanic battery with a bell attached, and an open test-tube containing liquid chloride of palladium. The chloride of palladium is extremely sensitive to the presence of carbonic oxide gas; it absorbs the gas and precipitates metallic palladium; the deposition of the metal in the bottom of the tube makes the connection of the galvanic current, and at once rings the bell, which will not stop until the current is broken. The invention is found to work admirably for carbonic oxide gas, and the next thing is to devise a plan for disclosing the presence of carbonic acid gas.

THE FRANKLIN TELEGRAPH COMPANY.—This Company are reconstructing the lines on their main route through Broadway and Centre Street, New York, with unusually tall and heavy poles, and a large number of wires on cross-arms and glass insulators.

City and Commercial Notes.

THE Société du Cable Transatlantique Francais, Limited (in liquidation), give notice that the liquidators will pay off the whole debenture debt in cash on the 1st October next, from which date interest will cease to run. The transfer books were finally closed on the 4th inst. Notice is further given that the holders of share warrants are required to lodge, with their respective coupon sheets, such warrants at 26, Old Broad Street, on or before the 20th inst., when the same will be cancelled, and the bearers entered as members on the register.

The Eastern Telegraph Company's traffic receipts for the month of June amounted to £27,398, and to £29,926 in the corresponding period of 1872.

The traffic receipts of the Eastern Extension, Australasia, and China Telegraph Company, Limited, for the five months ending the 31st May, amounted to £86,605, and for the month of June, 1873, to £18,640. The Australian line was opened for traffic in October, 1872. After October next the total receipts for the corresponding period of last year of the three companies recently amalgamated will be published, with the current receipts of the Eastern Extension Company.

The total traffic receipts of the Great Northern Telegraph Company were, during June, 1873, 240,468 francs, and in the corresponding period of 1872, 214,796 francs. On the European lines—in 1873, 126,183 francs, and in 1872, 113,456 francs. On the China and Japan lines—in 1873, 114,285 francs, and in 1872, 101,340 francs.

At the first meeting, on Wednesday, of the Direct United States Cable Company, the Chairman (Mr. E. H. Lushington) stated that all the necessary funds have been raised, and that Messrs. Siemens are now engaged in purchasing materials for the cable. A ship is to be built for the laying of the cable. Mr. Joseph Sawyer was elected auditor.

The report of the Eastern Telegraph Company, to be presented this day, recommends a dividend of 5s. per share, making, with the three previous payments, a total dividend for the year at the rate of 7 per cent, and states that they have carried to the reserve fund £42,958, thus raising it to £82,844.

The directors of the Telegraph Construction and Maintenance Company notify that the transfer-books will be closed from the 14th to the 22nd inst., both days inclusive, preparatory to the payment of an *ad interim* dividend to all shareholders on the register on the 12th inst. of 12s. per share.

At the general meeting of the Oriental Telegram Company, held at the offices 140, Leadenhall Street, the manager stated that the business is progressing satisfactorily, and that he looks forward to a great future for the Company.

The prospectus has been issued of the Globe Telegraph and Trust Company (Limited), with a capital of £3,000,000, divided into 150,000 Six per Cent Preference shares of £10, and 150,000 Ordinary shares of £10, the object being to give effect to the desire of proprietors in the principal Submarine Companies for the consolidation of telegraphic property, so as to spread the investment as much as possible over a number of lines, and thus insure each shareholder against the possibility of sudden fluctuations from local contingencies. Shares of the various existing companies will be received in exchange for those of the Globe Company, and the following table is given of the rates at which the operation may be carried out:—

"Table showing the companies the shares of which will be accepted, and the rate at which Globe shares will be issued in exchange. All allottees will receive in respect of their subscriptions in shares of other companies shares of the Globe Company in equal proportions of the preference and ordinary capital:—

	Nominal amounts of existing shares.	Rate of Exchange for Globe shares.
Anglo-American (including French and Newfoundland lines)	Stock	Par equal to—Anglo-American Old Stock, £152 per cent; French Atlantic, £36 10s. per share; Newfoundland, £20 per share, exchange and reserve warrant.
Eastern	£10 ..	Par.
Eastern Extension ..	£10 ..	Par.
German Union	£10 ..	Par.
Indo-European	£25 ..	£20 per share.
Telegraph Construction	£12 ..	£36 per share.
Submarine Cable Trust	£100 ..	£125 per £100 certificate.
Submarine Company ..	Stock ..	£250 per cent.

"Shares in other telegraph companies will be accepted on terms to be agreed. Subscriptions in cash for the £10 preference and £10 ordinary shares will be received as follows:—£1 on application, £2 on allotment, £3 in one month, and £4 two months after allotment. These subscriptions will be applied, at the discretion of the directors, in the purchase of telegraph shares and securities, and for other purposes of the company."

Mr. Pender is the chairman of the company, and Lord Hay, Lord Monck, Sir James Anderson, Sir Daniel Gooch, Messrs. Julius Beer, George Elliot, Cyrus Field, and Massey are the directors. It is intended to establish a Telegraph News or Intelligence Department in connection with the Trust. This Trust is, we understand, preliminary to the object of ultimately consolidating all the companies into one. Mr. William Abbott has addressed the following remarks to his clients:—

10, Tokenhouse Yard, London, E.C., July 11, 1873.

"Dear Sir,—I have much pleasure in forwarding to you the prospectus of 'The Globe Telegraph and Trust Company, Limited.'

"This undertaking offers to the shareholders of telegraph companies a comprehensive scheme of consolidation, which will give increased strength and stability to their property, and having been organised by the most influential leaders of telegraphy, its success is assured.

"By the adoption of the system of Preference and Ordinary Shares, the undertaking affords to those who desire a practically guaranteed *quarterly* dividend, a most favourable opportunity for investment, as the Six per Cent Preference Shares may be regarded as a freely negotiable mortgage on consolidated cable property, with a margin of security of 100 per cent on present values.

"The Ordinary Shares have distinct merits which will recommend them to the more speculative proprietor.

"It is unnecessary to enlarge upon the great advantages of amalgamation, the principle is universally acknowledged to be especially beneficial to telegraph property; I therefore confidently recommend this scheme to your careful consideration, and advise you to tender your Cable Stocks for conversion upon the terms given in the form for the exchange of shares, which accompanies the prospectus.—Yours faithfully,

"WILLIAM ABBOTT."

The Great Eastern was advised as having reached Heart's Content on June 29th, with the new Atlantic Cable, the voyage being the most successful yet made. Captain Halpin is of the opinion that the cable will last twenty years.

An extraordinary meeting of the Cape of Good Hope Telegraph Company (Limited) is called for the 23rd instant, "for the purpose of considering, and if approved, of ratifying, a certain agreement entered into by the company's attorney at the Cape for the sale of the company's undertaking and all its property in the colony of the Cape of Good Hope to the Government of the said colony, and to authorise the directors of the company, and the trustees of the main line subsidy, to do whatever may be necessary or expedient for the purpose of carrying out such agreement."

NEW JOINT-STOCK COMPANY.

The following new Company has been registered in accordance with the provisions of the Limited Liability Act:—

THE MAGNETICO COMPANY, LIMITED. Capital £50,000, in £5 shares.—The purchase of letters patent for improvements in magnetic electrical apparatus is the object intended by this Company. The subscribers (who take one share each) are—W. Eckersley, 3, Victoria Street; James Loutitt, Greenwich; Edwin Bishop, Norwood; David Parry, Blackheath; W. D. Ruck, Greenwich; H. B. Spiratt, 2, Walbrook Buildings; and B. T. Norton, Church Street, Twickenham.

TELEGRAPH SHARE LIST.

Amount per Share.	NAME OF COMPANY.	Amount paid up.	Closing Quotations.
£		£	July 12
Stock	Anglo-American (Limited)	100	139—141
10	Brazilian Submarine	7	2—1½ dis.
10	Cuba	All	9½—10
10	Direct Spanish	9	½dis.—½pm
20	Direct United States Cable	8	
10	Eastern (Limited)	All	9¼—9½ xd
10	Ditto New	All	9—9½
10	Eastern Extn. Australia and China	All	8¾—9 xd
10	Great Northern	All	10—10½ xd
25	Indo-European	All	14—16
10	Mediterranean Extension (Limited)	All	5½—6
10	Do., 8 per cent Pref...	All	11—12
20	New York, Newfoundland, and London	All	21¼—21¾
8	Reuters	All	10½—11½
20	Société Transatlantique Francaise ..	All	33—33½
Stock	Submarine	100	230—240
1	Do., Scrip	All	2¼—2½
10	West India and Panama	All	7—7½
10	Do., 10 per cent Pref.	5	½—1 pm.
1000 dls.	West Un. U.S. 7 per cent 1st M.B.	All	91—93
10	Hooper's Telegraph Works	All	13½—14
50	India-Rubber and Gutta Percha ..	All	34—36
Cert.	Submarine Cables Trust	100	111—115
12	Telegraph Construction	All	33¾—34¼
100	Ditto Ditto 7 per cent Bonds	100	102—104

Patents.

3548. W. Young, of Middlesex. *Improvements in electric telegraph apparatus, partly applicable for printing and producing stereotyping and printing surfaces.* Dated November 26, 1872. My improvements consist in the construction, first, of an apparatus which I denominate a mechanical typographer, and intend should be used for producing stereotype plates for printing newspapers, books, and other ordinary printed matter, and also as a mechanical writing or printing machine; secondly, of an apparatus very similar to the former, but provided with some additional mechanism to allow of its being used as a commutator for telegraphic purposes in electrical connection with; thirdly, another apparatus similar in some respects to the former or second apparatus, but otherwise not having any keys or treadle, and so constructed as to admit of its being used as a recording instrument or apparatus in electrical connection with the above-mentioned "commutator" for telegraphic purposes.

3565. H. Bezer, of Lee, Kent. *Improved apparatus for registering the distances by persons travelling in any vehicle, the number of travellers, and the distances travelled by the vehicle itself.* Dated November 27, 1872. The weight of a person and the revolution of a wheel producing an electric current and marking paper.

3586. G. Haseltine, of London, Doctor of Laws. *Improvements in printing telegraph apparatus.* A communication from Elisha Gray and Enos Melancthon Barton, both of Chicago, Illinois, United States of

America. Dated November 28, 1872. The objects of this invention are to retain the advantages resulting from the use of to and fro (positive and negative) currents, and to dispense with the use of a main battery and pole changer at every station, excepting at the station where the principal instrument is placed; to render the pole changer capable of being controlled by an operator at any point on the line; to dispense with the employment of a switch, and provide an instrument which shall be ready for use at all times either for transmitting or receiving messages, and which shall always be adjusted to the strength of the batteries, self-stopping, and self-correcting; and it consists in an automatic pole changer, in a novel arrangement of the disc or "sunflower" and the keys connected therewith in relation to certain circuits and currents, and in an automatic electro-unison stop and shunting device.

3600. P. W. Seymour, of Surrey. *Improvements in magnetic therapeutic plasters.* Dated November 29, 1872. The invention consists in forming a therapeutic plaster of a composition of iron filings and any suitable adhesive matter spread upon a woven fabric, said iron filings being afterwards magnetised.

UNITED STATES.

137,556. Robert M. Lockwood, New York, assignor to William H. Sawyer, same place, and Frank L. Pope, Elizabeth, N. J. *Galvanic Battery.* Application filed December 6, 1872. The negative element, consisting of a copper wire arranged in a horizontal flattened spiral, is held within or between the compound solutions, for the purpose of maintaining a separation of the two fluids. (1). The method of effecting or maintaining a separation between two dissimilar liquids in a galvanic battery, by means of the influence of an electric current traversing the negative element of said battery, substantially as herein specified. (2). The continuous spiral wire, c, c^1, c^2, c^3, forming the negative element of a galvanic battery, and placed within the liquid, substantially as and for the purpose herein specified.

137,730. John E. Smith, New York. *Circuit for Electro-Magnets.* Application filed March 15, 1873. Armature lever near completion of its stroke brings a resistance into circuit, thus weakening force of current through magnet and lessening spark at circuit breaker. The combination of a resistance coil or medium and a circuit breaking spring or lever with the armature lever, or part or parts set in motion by an electro-magnet, the whole being arranged substantially as specified, whereby the resistance is brought into the circuit only as the armature completes its movement toward the magnet, and remains in the circuit until the latter is interrupted, essentially as and for the purposes herein set forth.

137,801. Frank Shurz, Paloma, Ill. *Binding screw.* Application filed December 11, 1872. The head of the screw is provided with ratchet teeth, in which a spring pawl fastened to the post catches and prevents the screw from turning back.

138,115. Elijah Harrison Austin, New York. *Subterranean telegraph line.* Application filed February 26, 1873. At suitable intervals, along lines of underground telegraph conductors, boxes are provided, in which the several wires are separated and supported in numbered notches of an insulated bridge, in order to facilitate the detection and repair of any faults in any of the lines.

138,316. José S. Camacho, Havana, Cuba. *Electro-Magnetic Induction Coil.* Application filed October 26, 1872. The armature of the primary magnet, provided with an insulated cross arm, is arranged to operate double-spring contact levers, reciprocally reversing, so as to alternately reverse the induced current in the secondary coil, while the starting-point of the current will be in the same direction, giving continuity of effect.

139,302. George D'Infreville, New York. *Electro-Magnetic Telegraph.* Application filed August 10, 1872. The line wire is in connection with the similar poles of the two batteries at its extremities, so as to neutralise the current when both keys are down. Local relays are in action when the main wire is interrupted, recording the interruptions from simultaneous depression of the opposite keys, the object being to transmit messages simultaneously in opposite directions.

139,376. Jean D. Digney, Theodore Digney, Henry Lartigue, and Henry Forest, Paris, France. *Electric Railway Signal.* Application filed March 20, 1873. Signal turned in one direction closes one break in an electric circuit, another break in which is completed through a plate fixed near or between the rails and a wire brush carried by locomotive. This circuit passes a magnet controlling a whistle, so that the signal being turned the whistle is sounded, calling engineer's attention thereto.

139,436. Isaac I. Tatom, West Point, Ga. *Insulator for Telegraph Lines.* Application filed December 7, 1872. The cylindrical glass insulator, divided so as to enclose the telegraph wire, is secured in a recessed hinged clamp, provided at its outer end with a pivoted latch, for locking the clamping jaws together, and at the inner end with a screw thread for fastening the whole to the pole.

Deposit on Zinc.—At a recent meeting of the Chemical Society, a paper, "On the Nature of the Black Deposit in a Copper Zinc Couple," by Dr. J. H. Gladstone, F.R.S., and A. Tribe, F.C.S., was read. As it had been suggested that the black deposit referred to contained more or less metallic zinc, the authors had instituted experiments to ascertain the truth of the matter. When the solution of copper sulphate is poured on the zinc, a deposit of pure copper is produced as long as the solution contains any of that metal. As soon, however, as the copper is exhausted, other reactions supervene: zinc oxide is formed by the action of the oxygen dissolved in the water, and metallic zinc is also deposited. Such a black deposit examined under the microscope is seen to consist of branches of crystallised copper studded with crystals of metallic zinc, the latter of which at once disappear if washed with a solution of copper sulphate. It would therefore appear that the black deposit on the copper-zinc couple as usually prepared can contain little or no metallic zinc. After the reading of the paper, Dr. Russell said that the statement, that as long as there was excess of copper sulphate in solution no zinc was deposited along with the copper on the zinc plate, was at variance with certain experiments he had made some time ago. When a zinc plate is immersed in a dilute solution of copper sulphate, it immediately becomes covered with a black deposit; but if the plate be moved about in the liquid so as to remove it from the solution of zinc sulphate formed in contact with it, the deposit immediately acquires a red colour. The black deposit, moreover, evolves hydrogen when treated with acid, whilst the red does not. Dr. Müller remarked that iron plunged into a solution of sulphate of copper gives at once a red deposit; moreover, any metal appearing black from being in a minutely divided state acquires its proper colour on being rubbed with an agate burnisher, but this black deposit does not. Dr. Wright observed that, *a priori*, it was quite possible that zinc and copper should be deposited together, since brass could be electro-deposited.

An act incorporating the New York Underground Telegraph Company has been passed.

The Hooper Cable Ship.—This vessel has been built specially for the Hooper Company, and is fitted with three iron cable tanks built into, and with the ship, thus rendering them an element of strength instead of a source of weakness, as instances on record. The largest tank is 53 feet in diameter, and each one is 30 feet deep. The *Hooper* is propelled by a double-bladed screw, driven by compound surface-condensing engines, the high-pressure cylinder being 52 inches in diameter, with a 48-inch stroke, and the low pressure cylinder 92 inches in diameter, the piston rods being carried up through the cylinder covers. The engines are placed well aft, and take steam from four circular multitubular boilers. Besides the ordinary screw propeller, the *Hooper* is fitted with a transverse screw, placed a short distance inwards from the propelling screw along the keel, and driven by a pair of powerful engines in a deck house. The object of this screw is for manœuvring the vessel whilst laying the cable when it is expedient to remain on one spot. The arrangement has been tried, and proves to be quite satisfactory; when the main engines are stopped, and the transverse screw started, the vessel can either be kept stationary or hovering about one particular point. The vessel is not without appliances for saving labour, both on deck and below; water is laid on throughout the vessel, and her saloon and cabin accommodation is excellent. She was built by Messrs. C. Mitchell and Co., of Newcastle-on-Tyne, in seven months. The engines were built by Messrs. Thomas Clark and Co., and the paying-out and picking-up apparatus are by the Vulcan Foundry Company. The *Hooper* has a speed of 8½ knots, although when laying the cable she will not be required to run at more than 5 knots per hour. When loaded with 5000 tons, and drawing 23 feet of water, she displaces 1500 tons of water. She will take 1200 tons of coal on board for an average trip. She carries many thousand fathoms of grappling rope, composed of seven strands, each consisting of seven wires, separately covered with Manilla yarn, likewise grapnels, buoys, and necessary adjuncts for grappling or buoying the cable, should such a contingency as a break occur. A fine wire apparatus for sounding has been devised by Mr. Hooper, and answer well for great depths. In paying-out, the cable is led from each tank in succession to a series of five grooved pullies, which it passes over and under alternately, each pulley being fitted with a strap break. The cable then passes round a drum 6 feet in diameter, fitted with a powerful strap break, and thence over the paying-out wheel, 4 feet in diameter, and placed at the stern, a dynamometer being used to indicate continuously the strain on the cable. The picking-up apparatus is situated near the bows of the vessel, and is worked by a powerful double-cylinder engine carried on the same framing as the winding apparatus. The electrician's room is placed below deck between the main and after tanks, whilst there is a small house on the deck for jointing and similar operations. The batteries are upon Sir William Thomson's improved principle, the bluestone liquor being contained in long-necked bulbs, whose openings are loosely stopped with tow, and the necks inserted in the charged cells, the exudation of the liquor being by capillary action. These are stated to be both economic and satisfactory. The apparatus is so arranged that signals can be transmitted through the cable, and insulation readings taken at the same time. Signalling apparatus is fitted throughout the vessel to facilitate instant communication from one department to another.

Phosphor Bronze Wire, and its Application to Telegraphic Purposes.—It has long been the aim to produce a wire which possesses greater conductive capacities than the ordinarily used iron wire, and of greater strength than copper wire, which, by its soft and ductile nature, requires—except for short lengths—to be supported. In the United States a compound wire is largely used, so called from its being made of steel wire covered with a sheathing of copper, its strength being regulated by the thickness of the steel, and its conductivity by the thickness of the copper covering. The manufacture of this wire, however, requires the utmost care in order to enclose the steel wire perfectly. A slight defect permits moisture to enter between the two metals, galvanic action sets in, and the wire corrodes. Messrs. C. J. A. Dick and G. A. Dick undertook a series of experiments with wire drawn of phosphor bronze, and the tensile strength these gentlemen obtained with this material led them to experiment also on the respective capacities of these wires (of varied compositions) for conducting electricity. Compared with iron wire, phosphor bronze wire showed more than double its tensile strength, and more than three times its conductive capacity. As to the manufacture or treatment of the metals composing the new alloy, Messrs. Dick found that the oxide or carbon,—the former by the oxidation which takes place whilst the metal is in fusion, or the carbon which is left from the polling process,—although contained in but very small quantity in the wire, nevertheless materially affects its qualities, and is particularly detrimental to its strength and elasticity; they therefore add an oxidising agent, if necessary, to evolve the carbon, and then a sufficient amount of reducing agent, such as phosphorus. Wire drawn from such metal will be found to be tougher and more elastic than wires formed of metal containing oxides or carbon; but yet greater strength and elasticity is obtained with alloys of copper and tin which are phosphorised, or, in other words, which contain a given amount of phosphorus. Although the conducting capacity is somewhat impaired by the presence of phosphorus, valuable compounds for electrical wires may be made when used within the following proportions:—(1). When not more than 2 per cent of tin is used, the component quantity of phosphorus may amount to not more than 0·5 per cent. (2). When not more than 4 per cent of tin is used, the component quantity of phosphorus may amount to not more than 0·2 per cent. (3). When 5½ per cent of tin is used, the component quantity of phosphorus must not exceed 0·125 per cent.

To Correspondents.

James Graves.—Mr. Sabine's, not M. du Moncel's, name is attached to the article and note. Our objection to your experiment is that it does not satisfy the conditions of the question. Practically *nor* theoretically should the needle of the galvanometer in your bridge arrangement be deflected; deflection would be against the principles of the bridge, and could arise only from thermo-currents. If a current is propagated by induction between the molecules of a conductor, then the opposition to inductive propagation is the amount of resistance. If electric resistance be frictional, the resistance or friction will most probably be subject to the laws of friction of gravitating bodies.

F. Hualoke Carpenter.—The details of galvanometric principle and construction form a part of the design of our Student's papers.

G. B. Crompton.—If the wire passes over public property. apply to Mr. Scudamore, Postal Telegraphs, London. In the case of private property the application would not be necessary.

F. G. A. R.—Our advertisement columns would be a good medium for the expression of your want. Write to Dr. Siemens.

BOOKS RECEIVED.

"A Treatise on the Strength of Bridges and Roofs." By Samuel H. Shreve, M.A., C.E. New York: D. Van Nostrand.

"The Gold-Yield of Nova Scotia." By A. Heatherington. Fiftieth Thousand. Trübner and Co.

"Elements of Natural Philosophy." By Profs. Sir W. Thomson and G. P. Tait. Part I. Macmillan and Co.

"Lectures on Light delivered in the United States of America," with an Appendix. By John Tyndall, LL.D., D.C.L., F.R.S., Longmans and Co.